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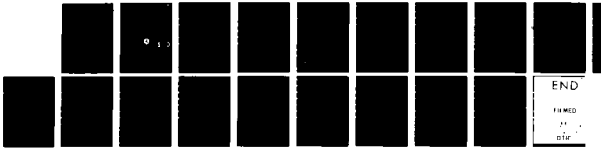

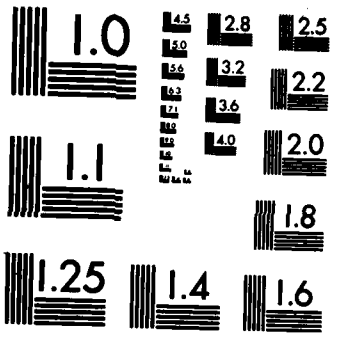

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SENSITIVITY OF SOME TESTS FOR ALCOHOL ABUSE: FINDINGS IN NONALCOHOLICS RECOVERING FROM INTOXICATION

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16. Abstract

A variety of measurements are sensitive to alcoholism; some may be applicable to screening programs, but more precise knowledge of sensitivity and specificity would help to select a minimal test battery. This study assessed the sensitivity of some tests for alcoholism to a single drinking episode. Fifteen nonalcoholic men, 26-59 years old, participated. On one evening they drank ethanol, raising their blood alcohol concentrations (BAC's) to 100-200 mg/dL for at least 2 h. At 0700 on the next morning, after 7 h of sleep, they ate breakfast, then completed a battery of performance tests. Blood samples were drawn at 0730 and 1130. The effects of alcohol, estimated by comparison of data with those obtained on another morning of the same week after an evening of abstinence, are summarized: Heart rate, during sleep and all the next morning, was higher; blood pressure, at 0700 and 1100, was unaffected. There was no effect on core body temperature, recorded hourly from 2400. The urinary excretion rates of catecholamines and ketogenic adrenal steroids were augmented by alcohol. The drug did not affect blood levels of gamma-glutamyl transpeptidase, glutamate oxaloacetate transaminase, high density lipid or total cholesterol, or uric acid. Performance tests affected by alcohol were number comparison, number addition, analysis of complex statements, and adaptability (from an air traffic controller selection battery). Tests not affected were abstract reasoning, digit code, digit symbol, short-term memory, hand steadiness, pursuit tracking, rod-and-frame, and 100-hue color sorting. Analysis of variance tests indicated that the order of presentation (alcohol first vs. control first) did not influence any of the results. The mechanisms of the alcohol effects are unknown but the possible influence of low BAC's (ca. 40 mg/dL) present during the test period cannot be ruled out.

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LIST OF TABLES

SENSITIVITY OF SOME TESTS FOR ALCOHOL ABUSE: FINDINGS IN NONALCOHOLICS RECOVERING FROM INTOXICATION*

A variety of government-sponsored educational and enforcement programs, as well as personal experiences with the drug, should ensure that U.S. automobile drivers are adequately aware of the threat of alcohol consumption to driving safety. Yet statistics continue to show that significant numbers of drivers killed in automotive accidents have been impaired by alcohol. In studies sponsored by the National Highway Traffic Safety Administration (41), 55 out of every 100 dead drivers were found to have blood alcohol concentrations (BAC's) above 50 mg/dL; of these 55, 47 had BAC's of over 100 mg/dL. In the laws of most states the lower level (above 50 mg/dL) is recognized as relevant evidence in trials for driving while impaired, and the higher level (100 mg/dL) is considered to be presumptive (prima facie) evidence of driving while under the influence of alcohol (42).

The occurrence of frequent alcohol abuse (drinking too much or at inappropriate times) by automobile drivers raises questions about its prevalence in other modes of transportation such as aviation. Data collected over the past 14 years by the Civil Aeromedical Institute's Aviation Toxicology Laboratory (47) indicate that the incidence of alcohol abuse by general aviation pilots is significantly less than that found in automobile drivers. Of 4,241 fatal general aviation accidents investigated, only 346 (8.2 percent) of the dead pilots had BAC's as high as 40 mg/dL, and there is some indication of a downward trend. Over 2,000 cases, representing 60 percent of all fatal general aviation accidents (48) occurring in the latter years of the study (1977-1981), underwent toxicological investigation; only 6 percent of these pilots had significant levels of blood alcohol.

Although these findings are encouraging, especially when they are compared to highway statistics, they are hardly ideal. Probably this incidence of abuse could be further reduced by more aggressive enforcement of the federal regulations that discourage it. But the misuse of alcohol by healthy individuals is not the only threat of alcohol to aviation safety. Alcoholism is another, possibly more serious, threat, because pilots who suffer from this insidious disease (we have no reason to believe that its incidence is any less in aircrewmembers than in the general employed population) may have decrements in mental function that persist even during periods of "sobriety." Although the Federal Aviation Administration (FAA) has made no definitive studies related to alcoholism as a cause of aviation accidents, there can be little doubt that the disease is inimical to safe flying.

There are no perfect strategies for detecting alcoholism in aeromedical applicants. A carefully taken medical history could be useful, as could a thorough examination for the signs of alcohol-induced pathology (1,12,24,26,34,37). But many alcoholics are cunning enough to recognize leading questions related to their problem. And the physical signs of abuse, when they appear, may not provide sufficiently early warning of serious decrements in either health or in flying proficiency. More reliable are biochemical tests that are sensitive to the pathological changes produced by alcohol, and performance tests that might be useful in screening for the earliest and most to be feared consequence of alcohol abuse, a decrement in mental function. A number of biochemical and performance tests

* Some of this material was presented at the annual scientific meeting of the Aerospace Medical Association, Bal Harbour, Florida, May 10-13, 1982.

have been recommended for the purpose, but to select all of them and others that may be devised later for inclusion in an alcohol test battery would be both impractical and uneconomical.

Certainly, some of the measurements that are sensitive to alcohol abuse (e.g., several for hepatic function; several for perceptual and motor performance) are so alike in scope and sensitivity that to use more than one of each group could be unnecessarily redundant. It is also possible that some measurements might be so sensitive to alcohol that they would be useless in a battery intended for the detection of prolonged abuse. As one group of investigators (11) has stated, "...alcohol is distributed uniformly throughout body water and consequently produces a variable pattern of toxic effects on multiple organ systems." Thus, alcohol concentration, dwell time, frequency of abuse, sensitivity of the tissue, and a host of other factors may affect the results of a biochemical or performance test. Some of the recommendations for certain tests have been based on studies comparing alcoholics with nondrinkers or control subjects who had abstained from alcohol before the evaluation period. Such experiments do not rule out the possibility that recent drinking might produce false positive signs of alcoholism in persons who drink infrequently. The study reported here evaluated this likelihood for some recommended tests and other tests that might be applicable to the screening of aeromedical applicants.

METHODS

Subjects. Nineteen paid male volunteers were recruited. Four of them became so nauseated on the morning after they drank alcohol that they were unable to complete the study; their data are not included in this report. Of the 15 other subjects, only 1 could be classified by questionnaire as a light drinker, 4 were medium drinkers, and 10 were heavy social drinkers. The questionnaire was based on one used by Cahalan (6). Average age of the subjects was 33.2; the oldest was 59 and the youngest was 26. Each had been evaluated by a medical officer, who based his examination on the FAA Class III medical examination form. Only one subject, number 10, showed any signs of medical deficiency; the examining physician's remark that this subject appeared to have an incipient emphysema was consistent with his difficulties in providing end-tidal breath samples for alcohol measurements. This subject also exhibited high rates of catecholamine excretion. He stated that he had taken no medication (tetracyclines were suspected) for several weeks prior to the study. Table I contains some of the data obtained from the subjects during the control (no alcohol) portion of the experiment.

Protocol. Each subject was studied during a 1-week period on two occasions; on a morning after he had drunk alcohol and on another morning after an evening of abstinence. All subjects were cautioned not to drink any alcohol over the weekend prior to the study and to drink only the alcohol provided by the investigators during the week of the study. (One prospective subject declined to participate after hearing these instructions). On both occasions the subjects reported to the laboratory at 1600 and remained in the laboratory until released at 1200 on the following day. Seven drank alcohol on the first evening and eight were given alcohol on the second evening so that the order of presenting the control and experimental treatments was approximately equal. The drinking and control periods began at 1930 and ended at 2330. Ten percent ethanol flavored with unsweetened lemon juice and a control mixture of juice and water were used. From 1930 to 2010 the subject consumed a priming dose of 39 g ethanol per M^2 body surface area. At 2030 his BAC was measured with a calibrated "breathalyzer" (Intoxilyzer, CMI, Inc., Mintum, Colorado).

A second dose of 13 g per M^2 was given at 2030 and BAC was measured at 2110 (20 min after finishing the drink). This regimen (a dose of 13 g and a BAC measurement after 20 min) was continued until a final dose was consumed at 2330, except that the dose of alcohol was reduced when it appeared that the BAC was rising at such rate that a concentration well over 200 mg/dL might result. The goal of the investigators was to produce a BAC of at least 100 mg/dL but no higher than 200 mg/dL during the 2330-2400 period. Each subject received eight drinks (including three priming doses) during the 4-h drinking period; the total dose consumed varied from 80-104 mL ethanol per M^2 body surface area.

Subjects slept in the laboratory from 2400 until 0700. They emptied their bladders at 2400 and were awakened at 0300 to collect the urine that had formed during the interim. Urine collection was continued. Collection periods were: 0000-0300, 0300-0700, and 0700-1130. Blood pressure (BP) was measured before each subject arose at 0700 and again at 1100. Venous blood samples were taken at 0730 and again at 1130. Rectal temperature was recorded hourly from a thermistor probe during the evening and on the following morning. Heart rate (HR) was recorded continuously via chest leads and Avionics Cardiocorders; recordings were analyzed with the Avionics Cardioscanner.

Chemical Analyses. Urine samples were preserved by adjusting the pH to 2 with HCl, freezing immediately and storing at -20°C until analyses were made. Blood samples were mixed immediately with heparin solution, centrifuged, and the plasma fraction stored at -20°C. Measurements of urinary catecholamines and of 17-ketogenic steroids (17-KGS) were carried out by methods used since 1971 (23). Blood constituents measured according to routine clinical techniques (3,10,32) were uric acid, total* and high density* lipid cholesterol (HDLC) gamma glutamyl transpeptidase (GGT) and serum glutamate oxaloacetate transaminase (SGOT).

Performance Tests. Each written test was available in two versions. One version was presented to the subject under each of the two experimental conditions. The Abstract Reasoning and Adaptability tests were the two elements of U.S. Civil Service Commission Test Number 157, Series 1 and 2, 1958. The other tests listed in Table I were obtained from Dr. Robert Carter of the U.S. Naval Aerospace Medical Research Laboratory, New Orleans, Louisiana. Other performance tests used were the Farnsworth-Munsell 100-Hue Color Discrimination Test (13), a Hand Steadiness (Motor Steadiness Kit, Marietta Apparatus Co., Marietta, Ohio), and the Oltman Rod-and-Frame field dependency test (9,29) using a portable apparatus (Cat. No. 12011) purchased from the Stoelting Company, Chicago, Illinois. The written tests were presented from 0800-0840 on each occasion and the color sort, hand steadiness and rod-and-frame tests were completed by 1030. Between 1000 and 1100 each subject completed 10 trials of the Air Combat Test. This test, based on game number 24 of the Atari video game Combat cartridge, has been described by Kennedy and Bittner (19). Subjects practiced this test for a total of 2 h on 2 days prior to the first experiment. Two video game modules and accessory equipment including joysticks and game cartridges were loaned by Atari, Inc., Sunnyvale, California.

Transportation to and from the laboratory was provided to each subject for the experiment in which he drank alcohol.

* Guilford Diagnostics; Trinder method; precipitant: Mg^{++}/dextran sulfate.

TABLE I. Experimental Subjects. Performance During the Control (No Alcohol) Experiment. See Legend for Test Identity and/or Bibliographic Reference.

SUBJECT NUMBER	AGE	ALCOHOL USE (Ref. 6)	TEST SCORES										
			A	B	C	D	E	F	G	H	I	J	K
1	27	M	7.75	50.7	29	10	9	65	49.3	75	129	177	12
2	30	H	0.0	49.0	17	12	-1.8	58	49.0	60	105	106	21
3	27	L	1.75	77.3	46	31	10.8	70	86.7	87	112	175	17
4	42	H	2.25	45.7	35	19	10.75	58	32.0	64	105	146	9
5	34	H	12.75	91.7	67	29	12.00	73	73.3	76	114	97	67
6	25	H	-2.50	52.0	30	18	5.00	58	80.3	68	103	180	9
7	28	H	5.00	77.0	69	28	3.25	60	68.0	72	112	177	27
8	26	H	4.75	66.7	51	16	4.25	48	53.7	57	124	178	24
9	32	M	12.00	60.0	58	8	9.00	69	37.0	76	129	115	13
10	47	M	4.75	60.0	57	12	6.50	50	16.0	60	116	58	100
11	59	M	0.75	56.0	28	18	-0.50	57	48.0	64	129	124	17
12	26	H	9.75	74.0	48	32	14.00	81	78.0	90	126	135	24
13	40	H	1.25	54.0	40	23	8.75	58	38.0	63	114	119	27
14	--	--	---	---	--	--	-----	--	---	--	---	---	--
15	28	H	-1.50	50.7	27	8	5.25	54	33.3	62	93	113	89
16	27	H	0.75	57.3	44	14	8.25	65	49.3	69	106	129	10

LEGEND: A - Abstract Reasoning; B-Number Comparison; C-Addition; D-Complex Statements(Baddeley); E-Adaptability; F-Digit/Code; G-Pattern Comparison; H-Digit/Symbol; I-Wechsler Short-Term Memory; J-Pursuit Tracking; K-Rod-and-Frame Test.

RESULTS

Blood Alcohol Measurements. Fig. 1 summarizes BAC's measured during the evenings when the subjects drank ethanol. The amounts of ethanol given to each subject varied according to the rate at which his BAC rose during the experiment; subjects who tended to exhibit a fast rise in BAC received lower doses according to that rate as the experiment progressed. As Fig. 1 shows, this titration of BAC levels produced BAC's above 100 mg/dL in all but three subjects by 2200 and in all subjects by 2230. Levels remained between 100 and 200 mg/dL until about 2400 when the last measurements of the evening were made. Fig. 2 contains the BAC's measured at about 2400 and at 0730 and 1100 the following morning. As expected, most of the subjects exhibited significant levels of blood ethanol at 0730, 8 h after their last drink of the evening before; all but two of them had BAC's above 40 mg/dL.

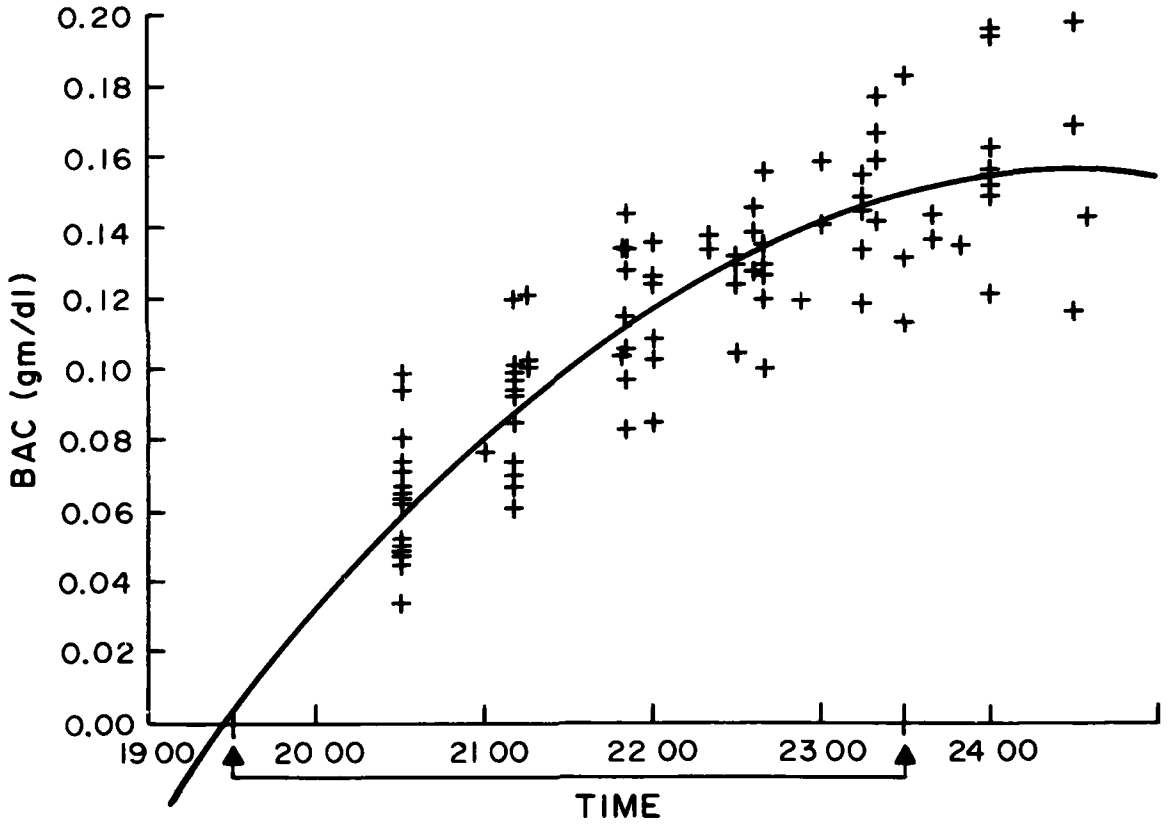

Figure 1. Blood alcohol concentration (BAC) in 15 male subjects given 10% ethanol in multiple doses over a 4-h period (see text). Time units are hours CDT; BAC units are in gm ethanol per 100 mL blood, measured by a CMI Co. Intoxilyzer. Arrows on the time axis denote first and last doses of ethanol.

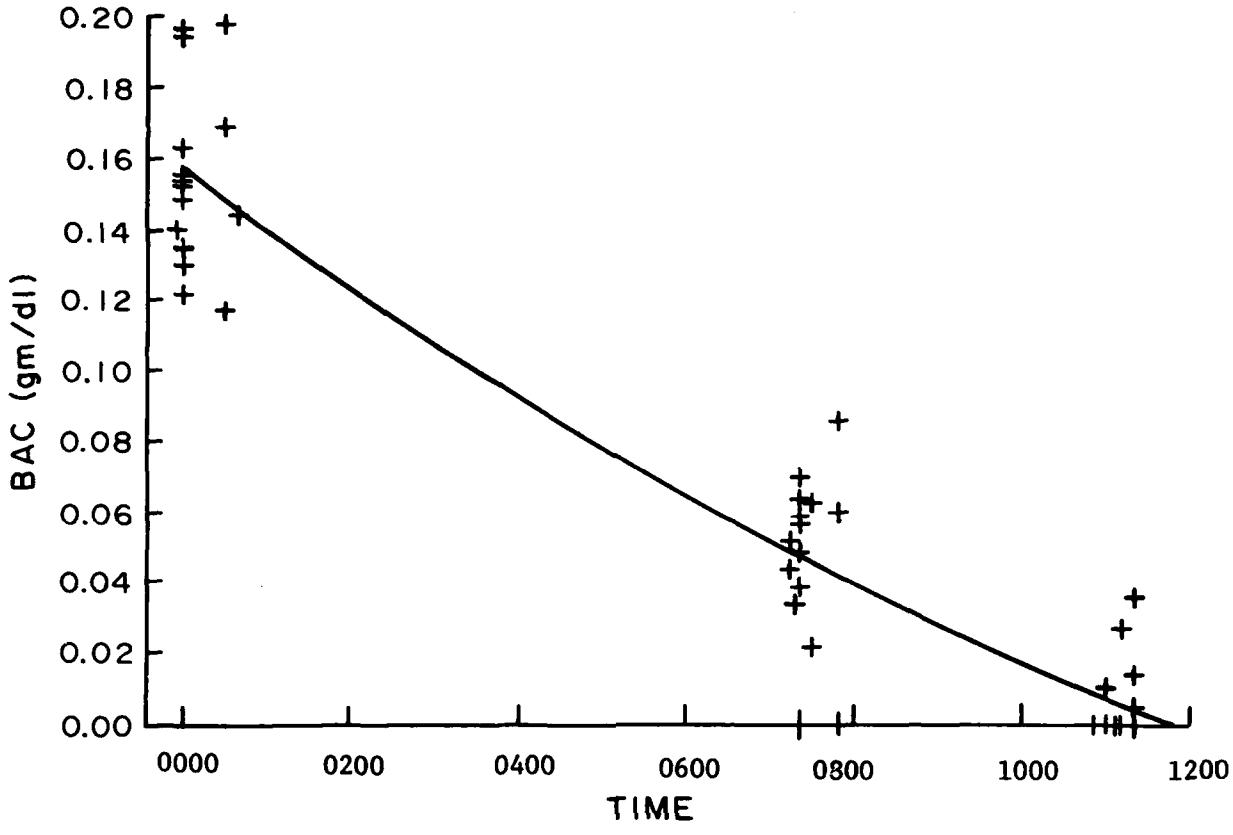

Figure 2. Blood alcohol concentrations on the morning after the experiment illustrated in Fig. 1. Data points at 0000 and 0030 are identical to those for 2400 and 2430 on Fig. 1. Note BAC's from 0730 to 1100. Ordinate and abscissa units are identical to those used in Fig. 1.

Signs of Ethanol Intoxication were apparent in all subjects by 2200 and all reported symptoms by 2100. Waking the subjects for urine collection at 0300 was far more difficult after they drank ethanol than during the control experiment. Four of nineteen subjects experienced nausea and vomiting between 0100 and 0300 and these symptoms continued intermittently until about 1100. No performance data were collected from these four subjects. None of the other subjects was asked about his symptoms on the following morning and no complaints were made.

Physiological Measurements. HR's were significantly higher when the subjects drank ethanol (see Table II). Average systolic/diastolic BP's were 115/73 at 0700 and 125/78 at 1100; there were no differences in BP's related to control and experimental conditions. Body (rectal) temperatures were all within the normal range and did not appear to be affected by alcohol.

TABLE II. Average Heart Rates During the Alcohol and Control Experiments. Beats Per Minute.

TIME:	19 - 24 h		0 - 7 h		7 - 11 h	
	CONTROL	ALCOHOL	CONTROL	ALCOHOL	CONTROL	ALCOHOL
	74.5	87.1*	61.5	78.8*	76.5	87.8*

* Significant, by t-test, at the 0.001 level.

Performance Tests. Results from the Farnsworth-Munsell 100-Hue tes indicated no color deficiencies in any of the subjects. Differences be- en the results obtained during the alcohol and control experiments were in: ·if- icant. There were no apparent residual effects of ethanol on hand stead -ss. Two of the subjects (see Table I) exhibited a field dependency, as meas by the rod-and-frame test but no effects of alcohol on this measurement we observed in these or any other subjects. The average Atari pursuit trac score during the control experiment (see Table I) was 135.3; on the mornings after subjects drank ethanol the average was 134.3. For this test and for all other tests used in the study there was no order effect detectable by analysis of variance.

Table III contains the average values of the results of the written tests. Scores in the number comparison and addition tests are reduced by about 10 percent after alcohol; scores in the complex statements and adaptability tests were reduced by 19 and 22 percent. These changes were statistically significant by the t-test. Levels of performance in the abstract reasoning, digit code, digit symbol, and pattern comparison tests were not significantly different under the two experimental conditions nor were there any consistent trends indicating subtle changes due to ethanol.

Biochemical Findings. Table IV presents the mean urinary excretion rates of catecholamines and 17-KGS under both experimental conditions. Significant findings were an enhanced norepinephrine excretion during the 0000-0300 collection period, an increased excretion of steroids during the 0300-0700 period, and a decrease in the excretion of epinephrine during the 0700-1130 period. These changes were apparently superimposed on more-or-less normal patterns of circadian rhythms for these compounds.

In blood samples taken at 0730 and 1130 (8 and 12 h after the last dose of alcohol), values for uric acid, SGOT, serum GGT, total cholesterol, and HDLC were within normal range and there were no apparent effects of drinking on these variables.

TABLE III. Performance Averages of 15 Subjects on a Morning After an Evening of Drinking (Alcohol) Compared to Performance on Another Morning After an Evening of Abstinence (Control). Level of Significance (P) Was Derived From the t-Test.

CONDITION	ABSTRACT REASONING	NUMBER COMPARISON	ADDITION	COMPLEX STATEMENTS	ADAPTA-BILITY	DIGIT CODE	PATTERN COMPARISON	DIGIT SYMBOL	WECHSLER S.T. MEM.
Control	3.97	61.47	43.07	18.53	6.97	61.6	52.8	69.5	114.5
Alcohol	4.87	54.76	38.67	15.07	5.42	57.3	46.63	66.4	112.6
P*	NS	.05	.05	.01	.05	NS	NS	NS	NS

* Level of significance.

TABLE IV. Urinary Excretion of Catecholamines and Adrenal Steroids After Consuming Alcohol (ALC) and After Consuming a Nonalcoholic Control Mixture (CON). The Collection Periods Are Labeled in Local (CDT) Time. Units of Average Excretion Rates Are µg/h for Catecholamines and mg/h for 17-Ketogenic Steroids.

	EPINEPHRINE		NOREPINEPHRINE		17-KETOGENIC STEROIDS	
COLLECTION PERIOD	CON	ALC	CON	ALC	CON	ALC
2400-0300	968	958	3233	7540**	295	435
0300-0700	585	666	3500	3952	253	380*
0700-1130	2028	1412**	4046	4881	500	444

* Difference between means significant at P 0.05 level.

** Difference between means significant at P 0.01 level.

DISCUSSION

Aviation activities are highly susceptible to alcohol abuse. Many of the workforce--aircrews, air traffic controllers (ATCS's), and others--must maintain the highest levels of proficiency to meet standards of safety and economy; alcohol threatens that proficiency (45). Those who abuse alcohol may suffer sensory defects (15,27,43), mental impairment (4,21,30,31,33), and loss of health (1,34, 37,45,46), all of which can adversely affect the skills and judgment necessary for safe flying.

Crewmembers are discouraged by the "8-hour rule" of Federal Aviation Regulations, Part 91.11, from flying within 8 h after consuming the drug--discouraged but not prevented because: (i) the rule is difficult to enforce, and (ii) although it provides a guideline for the prudent drinker the rule does not allow time for complete metabolism of large quantities of alcohol (see Fig. 2). Crewmembers can become educated to this latter deficiency but without objective tests for compliance we must rely on the flyer's sense of professionalism; we may do so with some confidence in the case of the air carrier pilot who depends on aviation for her/his livelihood. The general aviation population, however, which contains all of the nonprofessional flyers may not be so dependable (47).

Possibly then, any further reduction in the rate of alcohol misuse by air crewmembers can be obtained only through more explicit guidelines and more vigorous enforcement. Clearly, the intent of the present rule is that people should not fly when their BAC's are above a safe level but no means of assessing the BAC is provided for in the existing regulations. A precise and accurate method for that is now available. It is noninvasive, requiring only a sampling of the breath, and evidence obtained by the method is admissible in the courts of all states. Thus, there is legal precedent for applying the method in the field of transportation; today the 50 states, the District of Columbia, Puerto Rico, and the Virgin Islands all have an implied consent law as a deterrent to operating motor vehicles while intoxicated, and there seems no barrier to applying the implied consent principle to federal regulation (42).

Strengthening the Federal Aviation Regulations and providing for objective means of enforcing them may reduce accidents caused by the episodic form of alcohol abuse but this strategy offers less protection against air crashes caused by victims of the chronic form of abuse. Alcoholics suffer more or less permanent decrements in flying proficiency, decrements that do not depend on the presence of alcohol in the blood. Although a high BAC--especially one discovered in a person who is about to act as an air crewmember--should raise suspicions of alcoholism, the disease could go undetected if the presence of alcohol were the sole diagnostic criterion. There are, however, other tests for alcoholism that are sensitive to biochemical changes (7,10,11,26,32,36) or to decrements in performance (1,4,15,21,27,30,31,33,43). Apparently these tests reflect pathologic changes for which a variety of mechanisms have been proposed (1,2,8,14,16,20,22,28,37,38,39,40).

The ideal alcoholism screening battery would be comprised of only a few tests selected from the large number available for maximum sensitivity and specificity. One approach to this selection process is to evaluate tests known to respond to chronic abuse for their sensitivity to a single episode

of heavy drinking. Those tests found responsive to the acute effects of ethanol or to the withdrawal period following acute intoxication could be eliminated from a battery intended for the detection of alcoholism.

We simulated as nearly as practicable a test protocol that might be applied during the morning hours to a nonalcoholic applicant who may have imbibed heavily on the previous evening. All of the data were collected during the period following the last drink; most were collected during the eighth hour of this period. Although our subjects were regular users of alcohol (see Table I) none had high levels of serum GGT, SGOT, or uric acid consistent with alcoholism (10,34) and none gave a history of compulsive drinking. Performance in the rod-and-frame test by two subjects was consistent with the performance of alcoholics but the diagnostic value of this test is in question (4).

A summary of our results and a comparison with results obtained from alcoholics by other investigators are presented in Table V. Note that timing may be an important factor in the interpretation of our results. For example, we found no effect of drinking on the chemistry of blood samples withdrawn 12 h after the drinking period and conclude that within that time frame there is little risk of confusing alcoholics and nonalcoholics by these measurements. We do not know, however, if the similarities between the control and withdrawal periods were due to nonresponsive systems or were obtained merely because more than 12 h are required for a response to become manifest. Other studies employing higher doses of ethanol and longer observation periods would help to answer the question.

Sympathoadrenal responses to ethanol were noted (see also Table IV). These findings consonant with those reported by others (5,25,36) support our conclusion that the subjects of these experiments were not alcoholics whose levels of plasma cortisol do not rise after a challenge dose of ethanol (25).

In contrast to the biochemical findings the results of performance tests indicate a greater range of sensitivity to ethanol (see also Table III). Whether the effects that were seen can be attributed to residual effects of the high BAC's found on the previous evening, to the presence of acetaldehyde during the testing period, or to low BAC's present during that period cannot be concluded from this study. We found no reports in the literature of experiments dealing with the effects of low BAC's on these particular tests. Assuming that our experiments represent a typical evening of drinking and the withdrawal period that follows we offer these findings as examples of changes in performance during acute withdrawal. Possibly, these deficits in performance are important to aviation safety. Changes in one subtest (adaptability) of the ATC selection battery are consistent with that possibility.

Tests for alcohol abuse often derive from complex biochemical and pathological responses to ethanol. For example, blood levels of folate may be low in the alcoholic because of nutritional deficiency but blood folate is also responsive to acute doses of alcohol, falling to low levels when the BAC is high (38) and returning to higher levels as the BAC declines. This is probably due to an effect of ethanol on pteroylglutamate transport. The results of psychometric tests may, of course, be affected by a sufficiently high BAC but in the absence of blood alcohol the results of some tests, notably those for memory loss, problem-solving ability, and abstract processing, may be abnormal only in those with the Wernicke-Korsakoff Syndrome (see Thomson and Ron, Ref. 1, p. 87) associated with changes in brain morphology.

TABLE V. Comparison of Findings During Withdrawal in Nonalcoholics (This Study) With Findings in Chronic Alcoholics (Other Studies).

TEST OR FUNCTION	EFFECTS* of Alcoholism	EFFECTS* of Withdrawal	REFERENCE**
BLOOD CHEMISTRY			
SGOT,GGT	+	0	11,32
Uric Acid	+	0	10
HDLC	+ (Variable)	0	26,37
URINE FINDINGS			
Catecholamine Excretion	?	Augmented	5,36
Cortisol Excretion	No Response	Augmented	25
PERFORMANCE			
Rod-and-Frame	+	0	4
Digit Symbol (Code)	+	0	1 (Acker)
Short-Term Memory	+	0	1 (Acker),33
Color Sorting	+	0	27,43
Pursuit Tracking	+ (Psychomotor Speed)	0	1 (Acker)
Addition	+	+	1 (Thomson/Ron)
Complex Statements	+ (Probably)	+	1 (Acker)
Adaptability (ATC Btty)	?	+	1 (Acker) (Thomson/Ron)
Abstract Reasoning (ATC Btty)	+ (Probably)	0	1 (Acker)
Number Comparison	?	+	1 (Acker) (Thomson/Ron)
PHYSIOLOGY			
Blood Pressure	+	0	34
Hand Steadiness	+	0	1 (Shaw)

* Legend: + = Higher or lower than normal; 0 = No effect observed; ? = Unknown.

** Review articles are referenced where possible.

*** Urine findings in the withdrawal period (this study) or in alcoholics after a challenge dose of ethanol.

Thus, some tests might be excluded from a screening battery because they do not clearly indicate the stage of alcoholism or because they respond only to late effects from which the alcoholic is unlikely to recover (Acker, op. cit.). Still other tests--e.g., measurements of GGT (3)--may be flawed because they respond to conditions unrelated to drinking or because, like some reported in Table III, they give false positive indications of alcoholism in nonalcoholics during a hangover period. Markers of greater specificity are possible; for example, several chemical derivatives of acetaldehyde have been found in alcoholics (17,18,39) and measurements of these compounds might be applied to estimates of the long-term metabolic load of ethanol. But even these tests, although they appear to be specific to alcohol abuse, may not be wholly unaffected by other metabolic sources of acetaldehyde.

In conclusion, the rationale for choosing a battery of tests rather than depending on a single test for the detection of alcoholism is that, collectively, the tests comprising the battery become more specific than their individual characteristics would indicate. Each test must possess a degree of specificity, however. Our results indicate that some tests, although flawed by their response to conditions unrelated to drinking, are not so sensitive to ethanol that they are affected by a single episode of heavy drinking. Some performance tests that do respond to acute withdrawal provide yet another illustration of the inadequacy of the "8-hour rule." Performance decrements reflected by these tests may be related to aviation safety.

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